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More Wealth from Agriculture

Utilization research and development in the Agricultural Research Service of the U.S. Department of Agriculture is concerned with finding new and improved uses for farm products, so that profitable new markets for the farmer will be created and present markets expanded.

The four Utilization Research and Development Divisions—the Eastern at Wyndmoor, Pa., near Philadelphia; the Northern at Peoria, Ill.; the Southern at New Orleans, La., and the Western at Albany, Cal.—have a professional staff totaling about 850, mostly chemists, chemical engineers, food technologists, and microbiologists. Each Division operates a large regional laboratory and some Divisions have research personnel in field locations. Thus, the Eastern Division includes research scientists stationed in Washington, D. C., and Beltsville, Md. Figure 1 shows a typical installation of a modern research instrument. J. M. Purcell is shown adjusting the Eastern Division's NMR spectrometer.

Some of the accomplishments of utilization research were described in an earlier report entitled "New Wealth from Agriculture" (*1*). The present paper summarizes briefly some additional accomplishments that have created additional new wealth from agriculture.

Research in the Eastern Division Laboratory

The earlier report (*1*) described some of the Eastern Division's research program on animal fats. This program is continuing, and from it are coming new chemicals of importance in lubricants, detergents, plastics, and in other large-use industrial fields (*2*). The epoxy compounds, stemming from research on the epoxidation (*3*) of the fatty acids of animal and vegetable fats and oils, are widely used as plasticizers to give heat and light resistance to plastics.

These epoxy compounds are also found in nature. The oil in the seeds of the exotic ironweed plant (*Vernonia anthelmintica*) contains 70% epoxy acids. This plant is now being grown experimentally in many parts of the United States by agronomists, while Eastern Division scientists are studying the oil. If the industrial potential for the oil of this plant continues to develop (*4*), it may be cultivated domestically for industrial use and grown on acreages now devoted to the production of grains or other crops now in excess.

In addition to industrial products and processes utilization research seeks to develop new food products and to devise new and improved methods of making existing products. The Eastern Division has been assigned a number of important commodities used principally for food—milk, meat, eastern fruits and vegetables, maple sirup, and honey. Some of the products developed from these commodities have not only helped agriculture and industry, but have lightened the burden of the kitchen chores that must be done by the American housewife. Eastern Division engineers pioneered the development of a new way of dehydrating

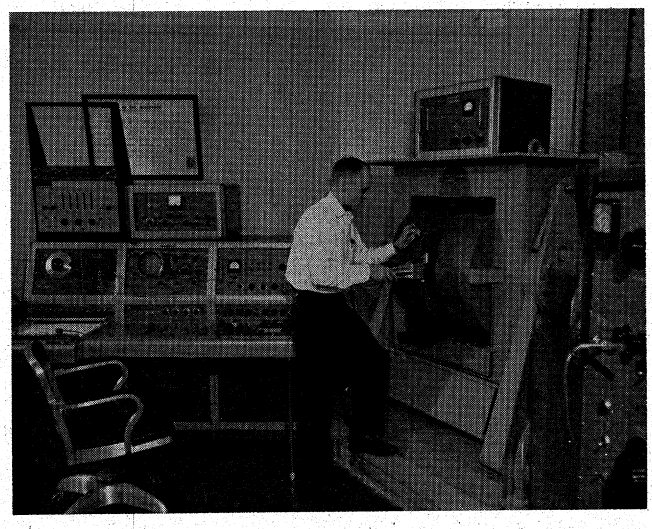

Figure 1. NMR spectrometer at Eastern Division.

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mashed potatoes (*5*). Now the product of this research—known as potato flakes—is being made by 12 American factories, and is available throughout the country. Potato flakes, potato granules, and other convenience potato products are restoring potatoes to the important place they once had in the American diet. The per capita consumption of potatoes had been on a downward trend for 50 years, but in the past few years has begun to climb again, and there seems little question that the phenomenal growth of processed potato products has been largely responsible—to the benefit of American potato growers.

A new and promising field of food dehydration now developing involves a technique called "explosion puffing" (*6*). Pieces of potato, carrot, beet, turnip, sweet potato, and apple can be prepared by this process. Conventional dehydration processes can also prepare foods like these, but dehydration is slow and 20 min to a half hour is required for cooking. Eastern Division engineers call the new product "quick-cooking dehydrated fruit and vegetable pieces," because they are ready to eat after 2–6 min simmering, depending on the product. These products are prepared by first partly dehydrating the pieces, then "exploding" them in a low-pressure chamber. The object is not to expand the pieces in size, but to put tiny channels in them by flashing off water vapor. When the pieces are returned to the drier, the rest of the water, which otherwise could be removed only by expensive and time-consuming methods, comes out quickly through these channels. When these dehydrated pieces are cooked, the water readily returns through the same channels. There are immense possibilities for these products. They may make an impact on the food industry such as potato flakes have already made.

The Northeastern and North Central States are especially interested in the paraformaldehyde pellets which were used commercially for the first time last season to disinfect maple tree tapholes (*7*). Years ago basic research on maple sap and sirup at the Eastern Division established the importance of sanitation in sap gathering and sirup production, in order to prevent the spread of quality-destroying microorganisms. Then it was discovered that microbial growth was responsible for the "drying up" of the taphole. Having established the real cause of this loss in the quantity and quality of maple sap, Eastern Division scientists gave the problem of preventing the growth to Michigan State University. The paraformaldehyde pellet developed there, which is simply inserted in the taphole at the beginning of the season, is credited with increasing sap yields by a third to a half in the 1962 season.

Some 30% of utilization research is to basic research. On potatoes, for example, while engineers are working out new dehydration methods, chemists are seeking exact knowledge of the composition of potatoes—knowledge that may provide the key to many processing difficulties that have been encountered. For example an automatic chromatography column is in operation 24 hrs a day, 7 days a week on the problem of amino acid content of potatoes.

Several lines of basic research on animal products, notably on milk and meat, are also being pursued. One study involves casein, the chief protein in milk. Casein is not homogeneous, but consists of at least three individual components, identified as α-, β-, and γ-casein. A calcium-sensitive fraction of α-casein can be identified; it is designated alpha$_s$-casein of milk (*8*) and can consist of three forms, A, B, and C.

Apparently, the genetic inheritance of the cow governs which ones occur in the milk of an individual cow. Since genes occur in pairs, a cow may yield one of six kinds of alpha$_s$-casein: alpha$_s$-AA, -AB, -AC, -BB, -BC, or -CC. This complexity of casein seems to be typical of other milk products as well. Figure 2 shows Dr. M. P. Thompson using the technique of zone electrolysis. This important experimental technique was responsible for revealing the genetic variation of casein.

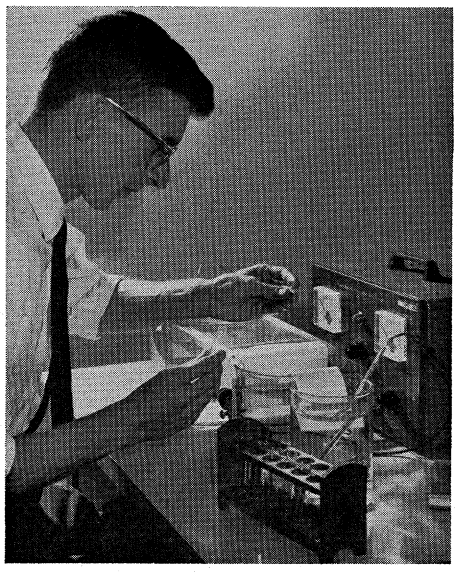

Figure 2. Zonal electrophoresis of milk proteins in starch gel.

Basic studies on meat have revealed that not all microbial lipases behave similarly toward meat fats. Thus at 35 °C *Staphylococcus* lipase releases saturated C_{16} acids from lard much more rapidly than *Pseudomonas* or *Geotrichum* lipase. The low activity of *Pseudomonas* is apparently due to its low ability to attack the 2-position in the glyceride, whereas that of *Geotrichum* is apparently due to low ability to attack saturated fatty acids (*9*).

Leather is another product on which an active program of utilization research is maintained. Synthetic substitutes have cut deeply into the market for leather and threaten to cut still deeper. New methods of preparing hides for tannage and new tanning materials may lower the price and improve the usefulness.

Two promising new tanning materials have been found. One is dialdehyde starch which is especially attractive because scientists at the Northern Division devised a practical way of making it from corn. Using dialdehyde starch as a pretanning agent, fine sole leather can be made in a week, whereas normal sole leather tanning takes six times that long (*10*).

The other new tanning material is glutaraldehyde, which produces soft leather resistant to a variety of agents that deteriorate ordinary leather (*11*). Glutaraldehyde is already in use by some tanners to make high quality garment leathers from sheepskins and shoe upper leathers from cattle hides.

Activities of Other Divisions

The Southern Division is probably best known for its research on cotton and deserves a lot of credit for the remarkable comeback this versatile fiber has made in recent years in competition with the synthetic fibers. Southern Division scientists have now invented stretch cotton (*12*). Once at a disadvantage because of its lack of elasticity, cotton can now be made into yarns with plenty of stretch and fabrics with plenty of give. It is not hard to imagine the vast new fields for cotton.

While the New Orleans group is carving out new markets for cotton, utilization research scientists at the Western Division in Albany, Cal., have devised a way of overcoming a serious limitation of another excellent fiber, wool. This is shrinkproofing treatment that employs interfacial polymerization (*13*); it is called the Wurlan treatment (Fig. 3). A diamine (A) dissolved in water and a diacyl chloride (B) dissolved in a solvent that does not mix with water interact rapidly at room temperature at the interface between the two liquid solutions to form a colorless polymer film.

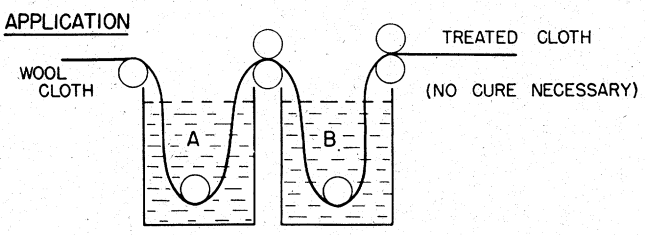

Figure 3. Principle of Wurlan treatment.

Continuous treatment of wool fabrics is accomplished by passing the fabric successively through the two solutions. Squeeze rolls remove excess liquid. After treatment the fabric is simply washed and dried. The ultra-thin polymer film is permanently anchored to the wool fibers and gives durable shrink resistance to machine laundering. A treated piece is practically identical in appearance, dimension, and feel to an unwashed piece, even after four 75-min washings. One 75-min washing badly shrinks an untreated sample.

The scientists at the Northern Division have found uses for surplus grains other than dialdehyde starch. An example is kraft paper containing up to 45% cereal starch xanthide or cereal flour xanthide, used as an additive with unbleached kraft wood pulp. It has up to nine times the wet strength and nearly three times the endurance of ordinary kraft paper (*14*). Moreover, the wet strength may be considered permanent, since it is not significantly changed when the paper is soaked for 24 hrs. Preparation of cereal pulps by a xanthation process followed by cross-linking has made possible the first use of grains as an integral part of paper. If this development opens up the vast paper industry as a market for grains, it will be an important contribution to our agricultural economy.

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